Appendix A

Further Details on Hydrogen and Derivatives

Intro to Hydrogen

Hydrogen (H_2) is a simple molecule that consists of two bonded hydrogen atoms.

Hydrogen is the most abundant element in the universe, making up approximately 74% of its mass.

On Earth, hydrogen is present naturally in vast quantities in water, as well as the atmosphere, and even in our bodies.

Hydrogen also occurs in almost all carbon-containing compounds, such as petroleum and natural gas.

Hydrogen is highly versatile and can be stored and distributed both as a liquid and gas.

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Using Hydrogen

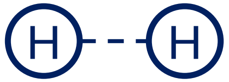
Although hydrogen is abundant, it is chemically bonded in naturally occurring feedstocks (including water and fossil fuels) so it must be produced or separated, which requires energy input.

Hydrogen is one of the most energy-dense fuels and burns without releasing harmful emissions and can therefore assist in tackling climate change if it is produced through methods that do not release CO_2.

The technology and infrastructure for distributing and using hydrogen is already present and has been demonstrated. Hydrogen has been in commercial use since the 1700s.

Hydrogen is highly explosive; however, this can be managed by appropriate risk management and project design (standard operating procedures, guidelines, and risk mitigation measures have been developed and adopted).

Hydrogen



H_2

Energy Rating of H_2

- 1 kg of H_2 = 33.3 kWh or 120 MJ
- 1 L of H_2 = 0.03 kWh or 0.01 MJ
- On this basis, 1 kg H_2 is equivalent to 110 ft^3 of natural gas, 0.02 bbl of crude oil, 3.8 L of gasoline, 3.4 L of diesel and 2.7 L of Jet Fuel.

*These calculations are based on equivalent units (100% energy efficiency of hydrogen) and LHV basis. The calculations are provided in the accompanying appendix workbook.

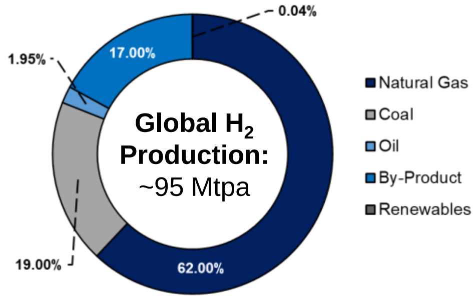
Potential Emission Savings by Fuel Switching

- Displacing 1 million ft^3 of natural gas will save 55 tonnes of CO_2
- Displacing 1 L of gasoline saves 2.4 kg of CO_2
- Displacing 1 L of diesel saves 2.7 kg of CO_2
- Displacing 1 L of jet fuel saves 3.9 kg of CO_{2c}

*These emission savings can be potentially realised by replacing these fuels with H_2

Current Production

- Presently, ~95 Mtpa of hydrogen are generated globally.
- Of this, 62% is from natural gas, 19% from coal, 17% as an industrial by-product, ~2% from oil, and <0.05% from renewables.



- **However, H_2 generated from fossil fuel generates 900 Mtpa of CO_2,** which is equivalent to the combined emission footprint of the UK and Indonesia.

Current Use

Oil Refining:
41 Mtpa (42% of H_2 supply)

Ammonia:
34 Mtpa (36% of H_2 supply)

Methanol:
15 Mtpa (16% of H_2 supply)

Direct Iron Ore Reduction:
5 Mtpa (6% of H_2 supply)

Renewable Hydrogen Transition

- The emission intensity of hydrogen production has prompted a recent shift towards renewable hydrogen production.
- **Renewable Electrolysis:** Hydrogen generation through renewable electricity-driven water splitting is an emerging pathway.

Classified as "green H_2 generation", the key advantage of this process over traditional fossil fuels is that:

i. It uses renewable energy and feedstocks (water, which can be sustainably supplied from desalination or wastewater resources).

ii. It does not produce any harmful by-products (only O_2 is produced that can be vented or used).

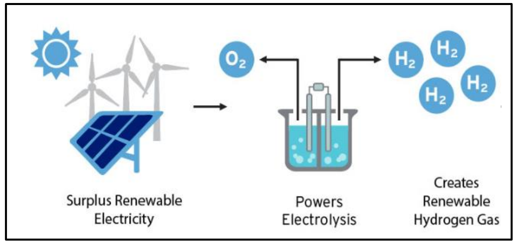


Figure 7. Schematics of "Green H_2" generation via renewable energy-driven electrolysis of water

- Presently, electrolysis contributes to ~0.05% of global hydrogen production. At present over 1,000 H_2 projects are in development globally, which includes a pipeline of 91 large-scale renewable hydrogen projects (>1 GW electrolyser scale – 0.2 Mtpa of H_2). Based on these committed projects it is expected that electrolysis will yield 25 Mtpa of green H_2 (2/3rd of the new capacity) by 2030.
- **Green H_2 is expected to remain the dominant pathway for large-scale hydrogen generation by and beyond 2050 (70% - 85% share of supply).**

Demand Growth – Emerging Market

- **Renewable H_2 can be used as a clean fuel and feedstock to decarbonise hard-to-abate sectors.**

80k fuel cell cars are in operation globally (~30% growth since 2022)

Green H_2 is being deployed for new ammonia generation, with ammonia demand expected to reach 100 – 150 Mtpa by 2050.

Green H_2 is being deployed to replace up to 10% of natural gas in global gas networks.

Green H_2 is also being deployed for future methanol generation, with methanol demand expected to reach 500 Mtpa by 2050.

Hydrogen-based SAF is expected to have a share of ~450 billion L of SAF required to achieve a net zero aviation sector by 2050.

By 2050, H_2 is expected to supply 2 – 3% of global electricity generation.

H_2 and its derivatives (ammonia and methanol) are expected to supply 50% of maritime fuels by 2050.

H_2 and its derivatives are expected to become major trade commodities (~150 Mtpa of H_2).

H_2 is expected to supply up to 10-15% of the Global Energy Supply by 2050 in a Net Zero Scenario

H_2 is emerging as a key vector for renewable energy penetration in hard-to-abate sectors

Emerging Global H_2 Economies

Globally, 25 countries & the EU Commission have adopted national H_2 policies, strategies and targets.

USA and Canada account for 17% of global demand. Both these countries have a H_2 policy and are pursuing renewable H_2 generation. Over 170 projects (16% of the H_2 projects being developed globally) are in development here – worth US$45 billion in investment by 2030.

The **EU** has a hydrogen production capacity of ~12 Mtpa (against a demand of 8.5 Mtpa). The EU has been pursuing a renewable H_2 policy. Recently the EU Commission announced plans for 20 Mtpa renewable supply by 2030 (10 Mtpa of which is to be imported). Key players are expected to be Germany, Netherlands, and Spain.

The **Middle East and North Africa (MENA)** region is also an emerging H_2 market. African regions are anticipated to be key export markets due to good renewable energy resources. Saudia Arabia is a key player, having recently made a positive FID on the "Neom Hydrogen Project" worth US $8.4 billion to supply 0.2 Mtpa of green H_2 as ammonia by 2026.

The renewable energy-rich regions of **South America (Brazil and Chile)** are expected to be large exporters of green H_2. The region is expected to potentially trade ~10 Mtpa of H_2 by 2050.

Hydrogen Economies in the Pacific Region

China is already a global H_2 giant - 33 Mtpa (~1/3rd of the global generation). At present, the country generates most of its hydrogen using coal (2/3rd). Recently, the region revealed its national H_2 plan that aims to deliver 0.1 – 0.2 Mtpa of hydrogen by 2025. The country is a leading market for H_2 vehicles and chemicals such as methanol. It is also a large-scale developer of electrolysers. It is expected by 2060, China could be generating 100 – 130 Mtpa of green H_2 (equivalent to 20% of its energy needs).

Japan has been a long-time proponent of a H_2 economy. Since 2023, the country revised its H_2 strategy that sets the target of supplying 20 Mtpa of $H_{2/}$ and ammonia by 2050 (mostly through imports). The regional H_2 demand is expected to be driven by the fuel cell vehicle market, the replacement of coal/gas-based power generation and green manufacturing (chemicals and steel). Japan also has a competitive advantage in the form of cutting-edge technology across the H_2 value chain. An example of this was the recently completed demonstration of liquid hydrogen export from Australia to Japan.

The Republic of Korea is also aggressively pursuing a hydrogen strategy. The country is aiming for ~2 Mtpa of Hydrogen production by 2030. A key market for H_2 is expected to be fuel cell cars (with ~6 million units expected to be adopted by 2040). Korean companies (such as Hyundai) are already developing H_2 technologies.

Singapore is expected to be a key demand hub for H_2. The country's hydrogen policy lays ambitions to import green H_2 to support the decarbonisation of the energy (which includes 50% generating of its power needs using by 2050) and maritime sectors.

Australia is anticipated to become a global hydrogen superpower. The Australian government is actively pursuing a H_2 strategy which has seen a recent announcement of A$2 billion in funding to support H_2 projects in addition to a A$6 billion investment in the last few years (both federal and state levels). That has resulted in a pipeline of 106 projects (~8 Mtpa by 2050) which are expected to leverage up to A$300 billion in capital investment. Most of these projects are for export (ammonia, methanol, and green steel) with H_2-based mobility, power generation, and natural gas replacement emerging as domestic H_2 markets.

*Note the above countries are provided as an example to illustrate the H_2 market in the Pacific. Other countries like Vietnam, Malaysia, Indonesia, Cambodia and New Zealand are also exploring their own H_2 strategies, however, are in the early stages.

Key Market Drivers

- Strong global policy push.
- Maturing hydrogen technology supply chains.
- Growing investment and incentives to stimulate the development of hydrogen projects.

Key Challenges

Despite the potential for H_2, there are challenges that needed to be addressed:

- **High cost of Green H_2**
  (Green H_2 is at present on average 2 - 5x higher than conventional H_2 from fossil fuels).
- **Scale of energy required**
  (efficiency of commercial electrolysers are still relatively low & thus relatively larger amounts of energy would be required compared to direct electrification).
- **Limited demand**
  (While markets for H_2 have been identified, they are yet to mature and start off taking large volumes of H_2).

References:
Refer to the accompanying appendices.

References - Hydrogen

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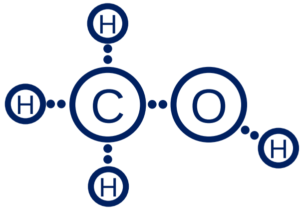
Intro to Methanol



Methanol (CH_3OH) is the simplest alcohol molecule, consisting of carbon, hydrogen, and oxygen.

Methanol can conveniently be stored and transported as a liquid at ambient conditions. Storage and transport using the same infrastructure as current fuels leads to lower related costs compared to gaseous renewable alternatives such as hydrogen and ammonia.

Feedstocks for methanol production include sustainable biomass (e.g., waste and residues from agriculture, forestry, energy crops, etc.) as well as hydrogen combined with carbon capture (e.g., direct air capture, industrial flue gas, biogas, and bioenergy).

Green methanol can achieve more than 90% emission reduction compared to fossil derived methanol depending on feedstock sourcing.[1]

When produced using green hydrogen, methanol is a versatile renewable energy carrier capable of power generation through fuel cell, reforming to produce hydrogen.

References:
Methanol Institute. Carbon Footprint of methanol. http://www.parliament.uk/documents/upload/postpn268.pdf (2022).

Using Methanol

Emissions released through the use and combustion of methanol are offset during its production by either carbon capture or repurposing of waste materials. The net lifecycle emissions of green methanol represents an emission reduction of more than 90% compared fossil fuels including gasoline, diesel, and marine fuel oils.

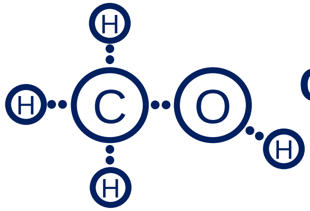
As a fuel methanol has a high octane rating. It can be blended with gasoline and diesel for use in internal combustion engines, direct use in modified diesel engines, and can be used as a substitute for heavy fuel oil for marine transport applications. Methanol has also been used for industrial and domestic heating such as boilers and burners.

Methanol is clean burning, producing less soot, particulate matter and NO_x compared to conventional fuels. It is also biodegradable with a half-life of less than 24 hr in marine environments. Marine heavy fuel oil, diesel, and gasoline, lead to 200, 240, and 1900 times more potent toxins in marine environments compared to methanol.

Methanol is a versatile raw material and chemical building block for producing a wide range of chemicals and products such as formaldehyde, acetic acid, plastics, paints, building materials, and car parts.

References:
Refer to the accompanying appendices.

Methanol



CH_3OH

Production

- $CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$
- $CO + 2H_2 \rightarrow CH_3OH$

Energy Rating

- 1 kg = 5.6 kWh or 20.1 MJ
- 1 L = 4.4 kWh or 15.9 MJ
- Octane rating = 110
- Methanol steam reforming
  $CH_3OH + H_2O \rightarrow 3H_2 + CO_2$

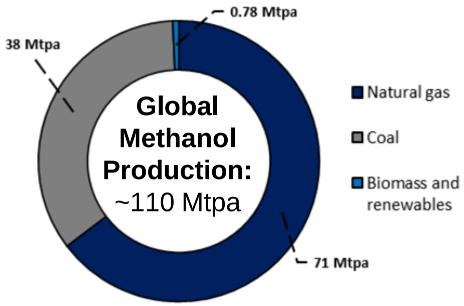
Fuel Emission Saving

- Replacing heavy fuel oil in large maritime vessels, methanol can save 1.3 tonnes of CO_2 per nautical mile.
- Replacing 1 tonne of marine diesel oil in small to medium vessels saves 3.8 tonnes of CO_2

*These calculations are based on equivalent units (100% energy efficiency of hydrogen) and LHV basis. The calculations are provided in the accompanying appendix workbook.

Current Production

- Presently, ~110 Mtpa of methanol are generated globally.
- Of this, ~71 Mtpa is from natural gas, ~38 Mtpa from coal, and ~0.8 Mtpa from biomass and renewables.



- **Emissions from fossil methanol production generates 300 Mtpa of CO_2**, which represents ~10% of the total emissions from the chemical industry

Feedstocks

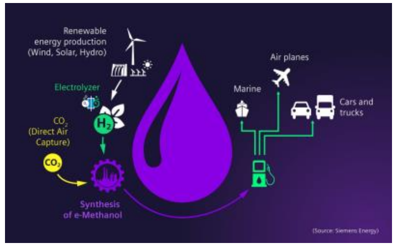
First generation:
Edible crops – corn, wheat, sugarcane, starch, and plant oil

Second Generation
Inedible crops, waste and residues from first generation feedstocks – Energy crops, agriculture and forestry residues, biogas.

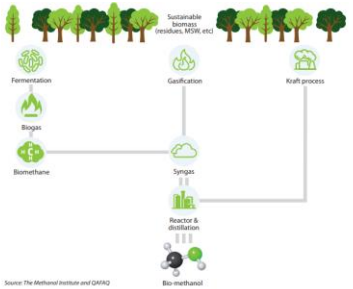
Third generation:
CO_2, Municipal solid waste (MSW).

Renewable Hydrogen Transition

- Methanol is fast becoming the leading alternative fuel for marine transport applications, and represents significant environmental improvement over existing fuels both in terms of carbon footprint as well as direct impact of spills and air quality on local ecosystems.
- **Renewable e-methanol:** Hydrogen generation through renewable electricity-driven water splitting, is reacted with CO_2 captured from the air or waste gas to produce methanol.
  i. It uses renewable energy and sustainable and scalable feedstocks (Water through seawater desalination, and CO_2 from the atmosphere)
  ii. E-methanol can achieve greater emission reduction and is not subject to additional sustainability considerations related to bioresources.



- **Bio-methanol:** Sustainable biomass feedstock is processed through typically gasification to produce syngas, followed by thermochemical reaction to produce methanol.
  i. This process employs similar techniques compared to fossil methanol production.
  ii. Bio-methanol can be produced at lower cost compared to e-methanol and does not require a supply of renewable energy.



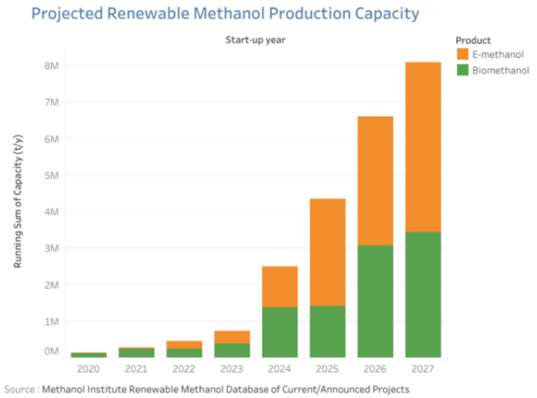
Demand Growth – Emerging Market

- **Renewable Methanol can be used as a clean fuel and feedstock to decarbonise hard-to-abate sectors.**

Green methanol market is gaining momentum with majority of interest being driven by maritime industries.

There are currently more than 21 green methanol producing facilities with a combined capacity of more than 0.7 million tons of bio and e-methanol per year.

Additional capacity from upcoming projects is to reach more than 10 million tons per year by 2027.

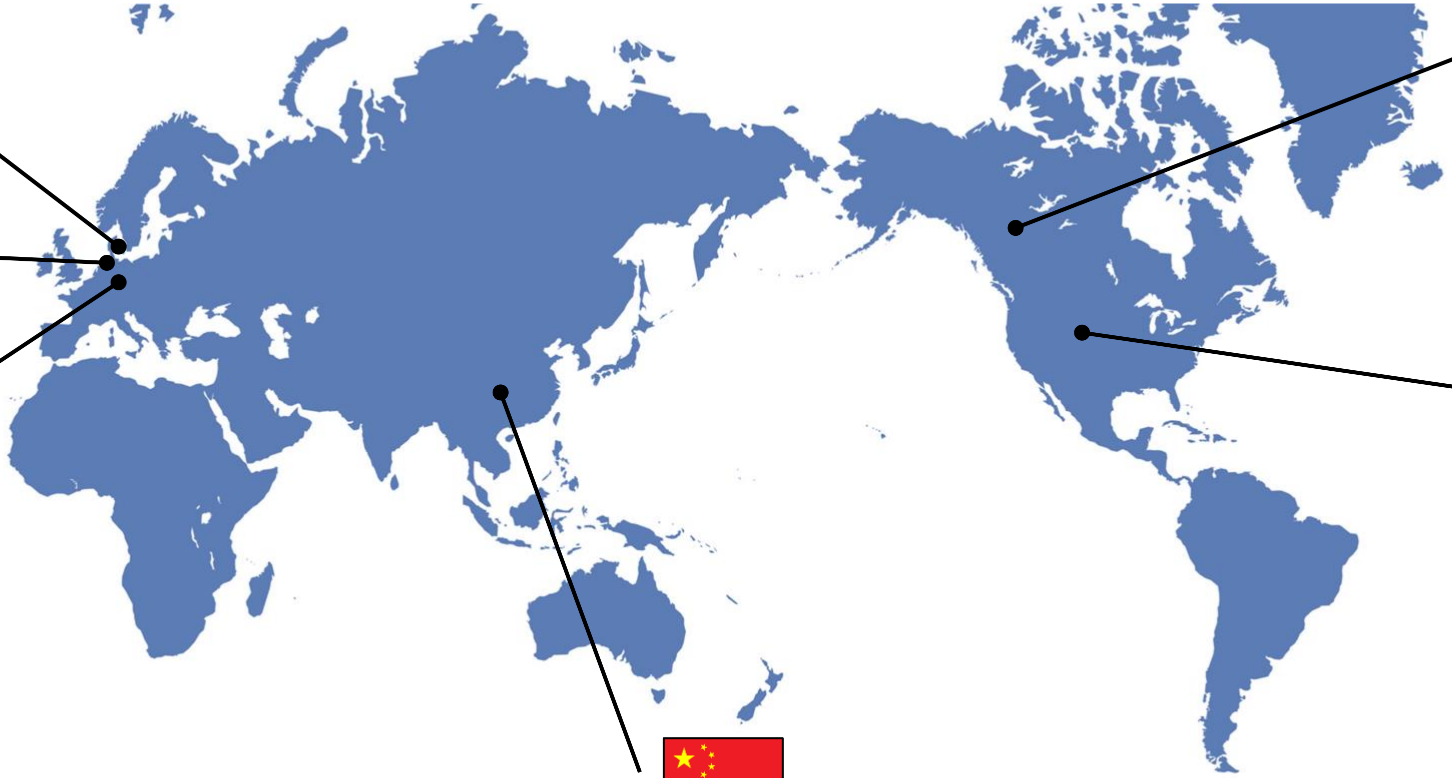


Green methanol – a promising green alternative to decarbonise hard-to-abate sectors

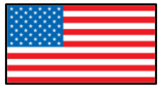
Denmark has 11 renewable methanol projects in various stages of operation.

Netherlands has 8 renewable methanol projects in various stages of operation.

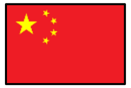
Germany has 8 renewable methanol projects in various stages of operation.



Canada has 5 renewable methanol projects in various stages of operation.



USA has 8 renewable methanol projects in various stages of operation.



China has 18 renewable methanol projects in various stages of operation.

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Intro to Ammonia

Ammonia (NH_3) is a colourless gas, composed of nitrogen and hydrogen. It is widely used in industry as a versatile chemical precursor for nitrogen-based substances.

The feedstocks to produce ammonia are hydrogen (produced mostly by steam methane reforming) and nitrogen (produced through air separation). These feedstocks are converted into ammonia via the Haber-Bosch process ($3H_2 + N_2 \rightarrow 2NH_3$)

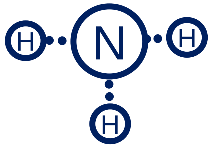
Ammonia can be easily compressed into a clear, colourless liquid, convenient for storage and transport via pipeline or truck.

Liquid ammonia has a large hydrogen storage ability (~18 wt.%) making it a valuable hydrogen carrier.

Ammonia's ability to be used in a blend or as a full replacement for petroleum or diesel, as well as its clean burning (the sole emission is water), highlights its promise as a clean fuel of the future.

References:
Refer to the accompanying appendices.

Ammonia



Production

- $3H_2 + N_2 \rightarrow NH3$

The H_2 is generated synthetically and N_2 is sourced from the air.

Energy Rating of NH_3

- 1 kg of NH_3 = 5.2 kWh or 18.8 MJ
- 1 L of NH_3 = or 15.6 MJ
- On this basis, 1 L of NH_3 is equivalent in energy to 2.8 L of compressed H_2.

Potential Emission Savings by Fuel Switching

- By using ammonia as an alternative shipping fuel, it is estimated there could be an emission reduction in this industry by 83%.
- By replacing diesel with green ammonia as an alternate fuel 100 kW diesel generator, carbon emission can be reduced by around 950 tonnes per year (assuming 24-hour use).

Current Production

- The current global production of ammonia is ~175 million tonnes per year.
- Over 80% is produced via the **Haber Bosch** process. This process involves the catalytic conversion of hydrogen and atmospheric nitrogen into ammonia.
- Hydrogen production accounts for 90% of the energy consumption:
- Hydrogen feedstock production breakdown: 70% = natural gas, 26% = coal gasification, 4% = oil + electricity.
- **Ammonia production directly accounts for 450 Mtpa of CO_2,** representing 1.8% of total global emissions.

Current Use

Fertiliser: Ammonia is the chemical precursor to nitrogen-based fertiliser, most notably urea.

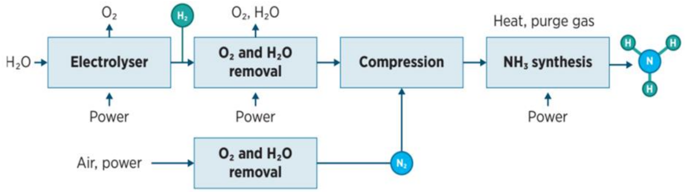
Refrigerant Gas: ammonia's high latent heat of vaporization, high volatility and ease of liquefaction make it suitable.

Water Purification: Ammonia is used to enhance chlorines disinfection properties.

Chemical Precursor: to plastics, explosives and other chemicals

Renewable Ammonia Transition

- Due to the high emission intensity and the growing demand of ammonia, methods to reduce its emission intensity are emerging.
- The transition into renewable ammonia production can be performed by Haber-Bosch electrification and hydrogen produced via Electrolysis, whereby renewable ammonia can be produced by using renewable electricity to produce hydrogen and power the air separation and Haber-Bosch processes.
- Electrifying the Haber-Bosch process through renewable energy ensures the replacement of the fossil fuel based H_2 supply and allows the use of existing infrastructure (existing Haber Bosch Plants).



Demand Growth – Emerging Market

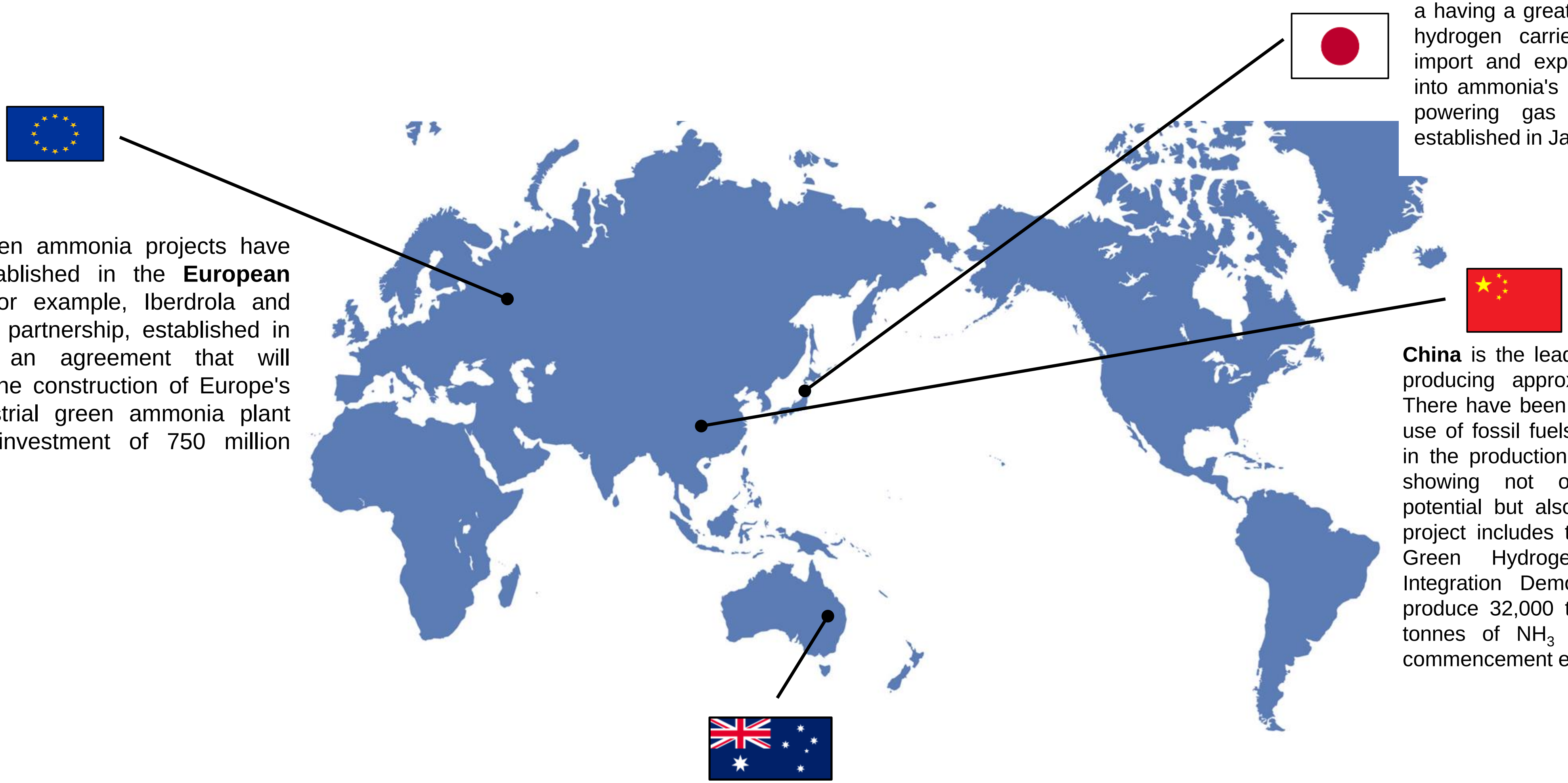
On top of continuing to meet the growing demand for fertiliser production, ammonia has been flagged for its potential as a clean fuel for electricity generation, transportation, and energy storage.

- **Energy storage:** Ammonia has advantages (economic, technical and environmental) over pure hydrogen as an energy carrier and for energy storage.
- **Electricity generation:** Ammonia has the potential to produce electricity through an engine system or an ammonia fuel cell. There is a potential and growing interest in using ammonia a diesel replacement in diesel engines. Ammonia fuel cells are being developed for its direct use in producing electricity or mechanical energy, they currently have a Technology Readiness Level of 3-4.
- **Transportation:** Ammonia is able to replace petroleum or diesel in internal combustion engines, showing its potential to be used as a clean fuel replacement. It has also been flagged with great potential for a clean shipping fuel due to its high energy density and relative storage and transportation ease.

Challenges

- Due to ammonia's higher ignition temperature, many engines need dosing of diesel of petroleum or require retrofitting to be able to effectively run on 100% ammonia.
- Ammonia combustion emits a relatively high level of NO_x, meaning mitigation strategies need to be implemented when ammonia is used as a fuel.

Green ammonia – a promising green alternative to energy storage and generation.



Japan has initiated R&D, flagging ammonia a having a great potential as an energy and hydrogen carrier, especially in terms of import and export opportunities. Research into ammonia's potential as a fuel, such as powering gas turbine, has also been established in Japan.

Many green ammonia projects have been established in the **European Union**. For example, Iberdrola and Trammo's partnership, established in 2023 is an agreement that will facilitate the construction of Europe's first industrial green ammonia plant with an investment of 750 million euros.

China is the leading producer of ammonia, producing approximately 50 million tons. There have been discussions to replace the use of fossil fuels with renewable electricity in the production of ammonia, with studies showing not only the decarbonisation potential but also a cost reduction. A key project includes the Da'an Wind and Solar Green Hydrogen Synthesis Ammonia Integration Demonstration Project. It will produce 32,000 tonnes of H_2 and 180,000 tonnes of NH_3 per year, with operation commencement expected in 2024.

With its enormous renewable energy potential, **Australia** has been flagged as having a future in leading green ammonia production. Various projects have been developed to deliver green ammonia to the global market. One key project includes Yara's Pilbara ammonia plant, which plans to produce ~3,500 tons of green ammonia annually by the end of 2024.

References - Ammonia

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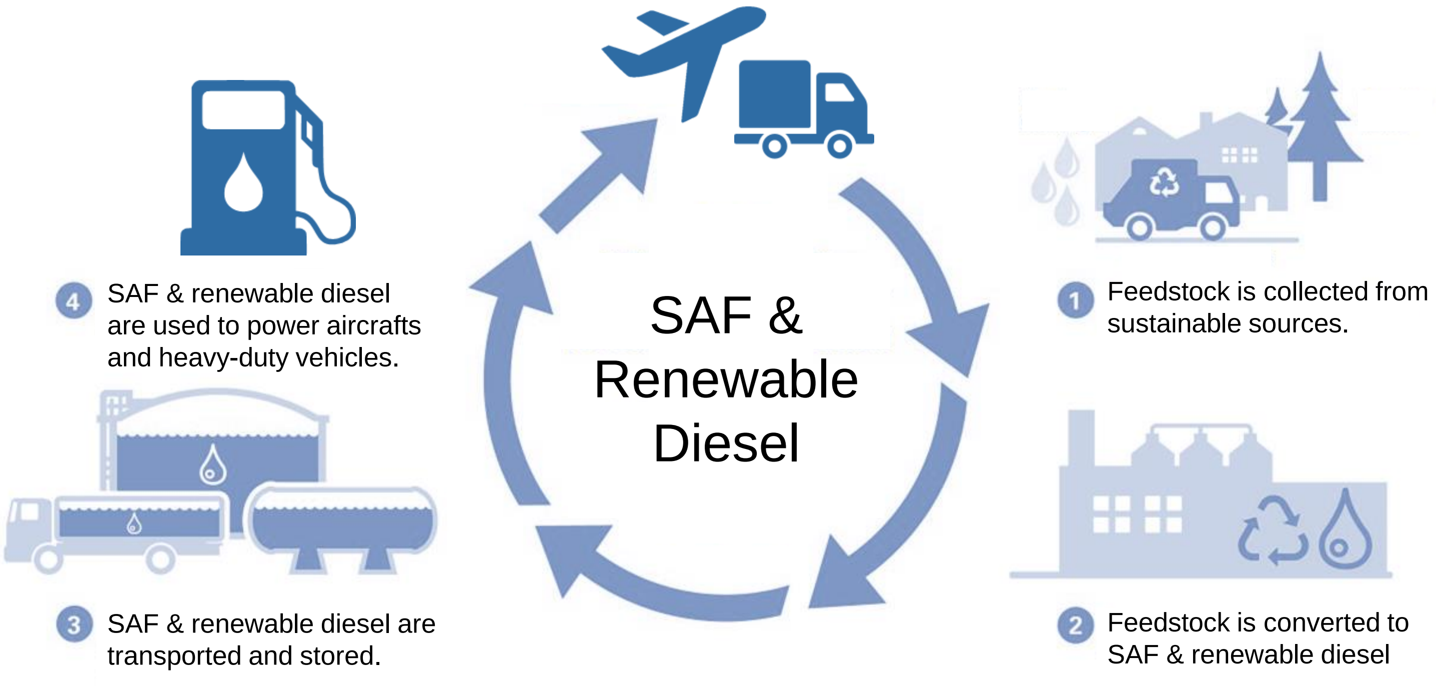
SAF & Renewable Diesel

Key to decarbonising aviation and heavy-duty transportations at scale and speed.



Intro to SAF & Renewable Diesel

The adoption of SAF & renewable diesel is a key part for hard-to-abate sectors such as aviation industry and heavy-duty transportations of achieving net zero carbon emissions by 2050.

SAF & renewable diesel are made from sustainable feedstocks such as biomass waste and captured or waste CO_2 emissions.

SAF & renewable diesel can reduce lifecycle carbon emissions by up to 80% compared to the traditional jet fuel, and renewable diesel has a 65% lower carbon emission intensity compared to conventional diesel.

SAF & renewable diesel are safe to use in existing engines and infrastructure.

References:
https://www.bp.com/en/global/air-bp/news-and-views/views/what-is-sustainable-aviation-fuel-saf-and-why-is-it-important.html
https://afdc.energy.gov/fuels/renewable_diesel.html

SAF & Renewable Diesel Production

Feedstocks
(biomass and CO_2)

Gasoline
(C_5-C_9)

Jet fuel
(C_{10}-C_{14})

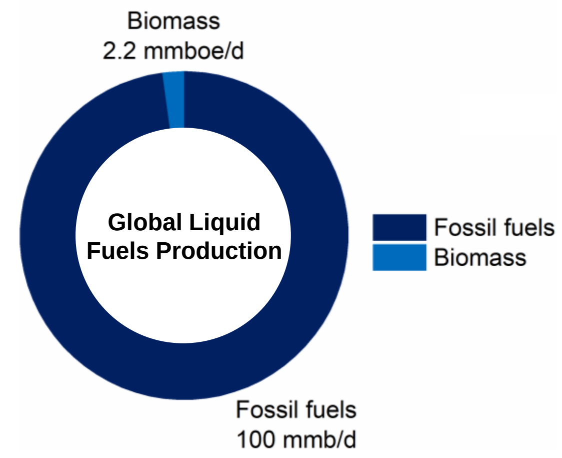
Diesel
(C_{15}-C_{22})

Synthetic fuels including SAF & renewable diesel can be produced through:

Biomass-to-Liquid (BtL)
BtL makes use of biological input as the carbon source.

Power-to-Liquid (PtL)
PtL involves the electrolysis of CO_2 with green H_2 and a reverse water gas shift reaction (RWGS) or directly in a co-electrolysis setup.

Current Production



mmb/d = million barrels per day
mmboe/d = million barrels of oil equivalent per day

- The current world liquid fuels production averages about 100 million barrels per day produced from fossil fuels.
- Liquid biofuels account only around 2.2 million barrels of oil equivalent per day.
- Almost all renewable liquid fuels (e.g., SAF & renewable diesel) are produced through the biomass-to-liquid pathway.
- Most of the production capacity is in the United States, while the rest are produced in Netherlands, Finland and Singapore.

References:
https://www.eia.gov/outlooks/steo/report/global_oil.php
https://afdc.energy.gov/fuels/renewable_diesel.html

SAF & Renewable Diesel Advantages

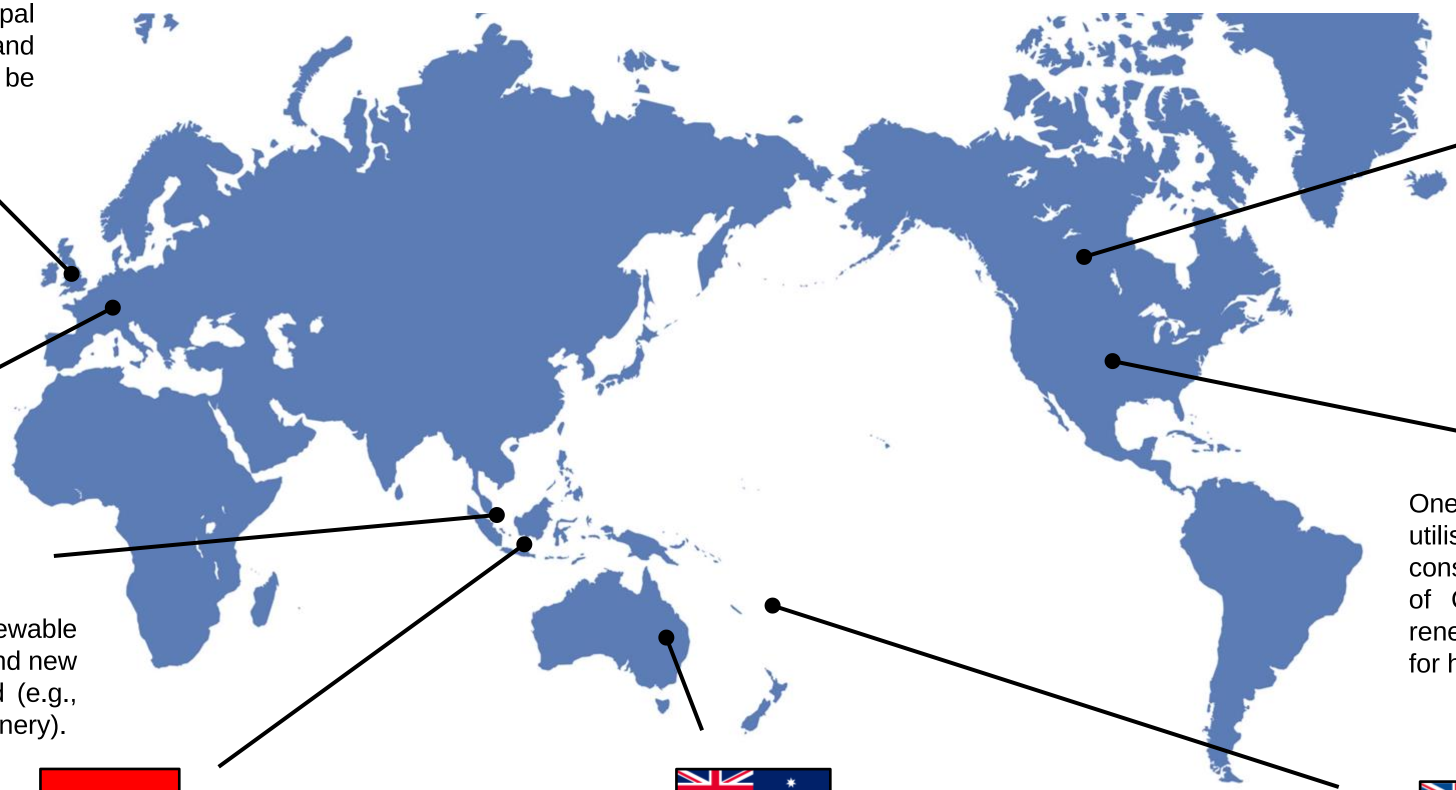
- SAF & renewable diesel are synthetic alternatives for fossil-based jet fuel and diesel – sharing similar chemical, physical, and thermal properties.
- SAF & renewable diesel can be distributed, stored, and used like conventional jet fuel and diesel, allowing them to be directly utilised without the need for retrofitting the energy supply/use.
- SAF & renewable diesel can act as a sink for CO_2, as they can be generated through the biomass-to-liquid pathway or power-to-liquid pathway via using H_2 from electrolysis and CO_2 from waste/captured resource.
- SAF & renewable diesel have a lower overall CO_2 intensity compared to the fossil-based counterparts. The emissions generated in the utilisation are offset by the emissions sequestered or captured during the growth of biomass and production of SAF & renewable diesel.

SAF & Renewable Diesel Market Opportunity

- SAF can be used as a drop-in replacement for fossil jet fuel using the existing aircrafts and airport infrastructure.
- Renewable diesel can be used as a drop-in replacement for fossil diesel in power generation using diesel generators and in mobility engines (cars, trucks, trains and small ships).
- SAF currently accounts for only 0.01% of global jet fuel use but is expected to reach up to 2% by 2025.
- The global SAF market size reached US$433.26 million in 2022 and it is expected to hit around US$14,824.13 million by 2032.
- The demand for renewable diesel is expected to increase to over 7 billion gallons by the end of this decade (~70 billion USD a CAGR of ~19%).

References:
https://www.precedenceresearch.com/sustainable-aviation-fuel-market
https://www.iea.org/reports/renewables-2021
https://www.marketresearchguru.com/enquiry/request-sample/22367336?utm_source=Karn_LinkedIn

SAF & renewable diesel are being increasingly deployed globally to decarbonise aviation industry and heavy-duty transportations.



Over ten SAF plants, utilising municipal solid waste, agricultural residues, and CO_2 from industry are expected to be commercial by 2030 in the UK.

The European Union countries host 16 renewable diesel generation facilities, that can generate up to 5.5 billion litres per year of fuel. These are mostly located in Netherlands, Italy and Spain

In Singapore, several SAF & renewable diesel plants are being developed and new partnerships have been announced (e.g., Neste's SAF & renewable diesel refinery).

Indonesia has the capacity in producing SAF called Bioavtur J2.4 at the Pertamina International Refinery Cilacap Unit.

Australia has plans to convert existing oil refineries to renewable fuels production facilities as SAF is gaining traction. Australia is also conducting R&D to shift to renewable diesel for heavy duty trucks and construction

Fiji has several bioenergy projects: Nabou Green Energy 10 MW plant using fuel wood, Energy Fiji Limited waste-to-energy plant in Central Viti Levu, and Fiji Sugar Corporation and Tropic Wood Industries bioenergy generation using bagasse and wood residues.

Airbus Canada, Pratt & Whitney Canada, and SAF+ Consortium collaborate on developing the next-generation SAF in Quebec.

One of the first SAF plants in the world utilising municipal solid waste has completed construction in Nevada. In addition, the state of California is the largest consumer of renewable diesel. Here the diesel is majorly for heavy duty vehicles and public transport

References:
https://assets.kpmg.com/content/dam/kpmg/uk/pdf/2022/11/sustainable-aviation-fuel.pdf
https://www2.pertamina.com/en/news-room/news-release/successfully-creates-bioavtur-j2.4-pertamina-supports-national-clean-energy-strategic-program

Opportunities and Challenges for SAF & Renewable Diesel in PICTs

Opportunities

- Potential utilisation in aviation and mining sector in the region
- Immediate solution to decarbonise hard-to-abate sectors in the region
- Increased energy security in the region
- Sustainable economic growth in the region

Challenges

- Limited theoretical feedstocks for SAF & renewable diesel production in the region
- Lack of regional climate commitment and goals
- Limited infrastructures to support SAF & renewable diesel value chain in the region
- Significant subsidies for fossil fuel industry in the region

References:
Deloitte, 2023, Sustainable Aviation Fuels in the Pacific.